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Improving the NWM-based tropospheric delay using real GNSS observations

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Numerical weather model (NWM) data set is a gridded meteorological data set with specific spatiotemporal resolution. The tropospheric delay above any station can be calculated with reanalyzed or forecasted NWM data sets for post-processed or near real-time applications. A major advantage of using NWM data set is to offer comparatively precise tropospheric delays for all GNSS applications, for which it is difficult to estimate them as additional parameters, e.g., for kinematic applications. However, as illustrated in many references, tropospheric delays, calculated with NWM data set alone, are unsatisfactory sometimes. Besides improving the calculation methods, external enhancement is an effective way to improve the precision of NWM-derived tropospheric delays. Thanks to the rapid development of GNSS-based Earth observing techniques with increasing regional and global GNSS ground networks, the tropospheric delays above any station can be derived from a large number of GNSS observations with continuously increasing spatiotemporal resolution. Although those stations are irregularly distributed and covered by regularly spaced grids of NWM data set, they can be used as a powerful external dataset to improve the precision of the NWM calculated tropospheric delays. In this early work, the NCEP (National Centers for Environmental Prediction) data set and GNSS observations of IGS stations in the European region during 2016 were used with two schemes. In the first scheme, we firstly generate surface 2D grid tropospheric delay products by only using the NCEP data set. Then, the delays above all grid-points are re-estimated with the contribution of delays derived from GNSS ground network. With this procedure the previously generated delay products can be significantly improved. In the second scheme, we take the tropospheric delay above a station as a random quantity whose a priori value is calculated with NCEP data set. With the theory of collocation, unknown delays above stations, whose a priori values are known, can be updated with the help of delays above known GNSS stations. Our results show that those tropospheric delays interpolated based on the new gridded delay product in first scheme or re-estimated in the second scheme are of attractive precision. For specific stations, taking the GNSS derived delays as reference, the precision improvement of new delays reaches up to about 50% in root-mean-square. Furthermore, precise point positioning is carried out as the first examination of the GNSS-improved tropospheric delay in positioning applications. Our first investigations show that the GNSS-observation-improved tropospheric delay will better serve GNSS positioning applications.